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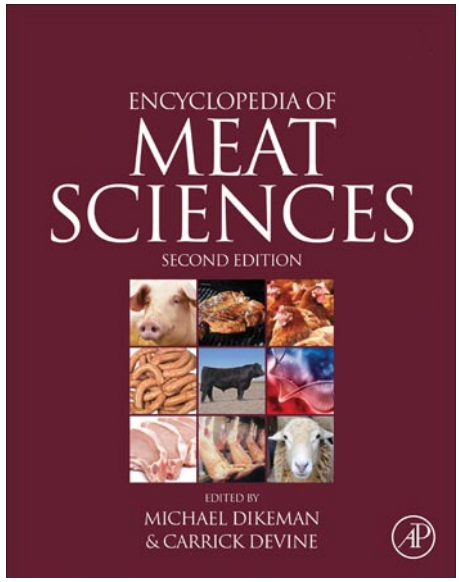

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Disease Control and Specific Pathogen Free Pig Production

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Infectious and Noninfectious Diseases

Diseases of pigs may have infectious or noninfectious etiologies. Infectious diseases are caused by pathogens, such as viruses, bacteria, or parasites. Noninfectious diseases may be hereditary, or of metabolic, nutritional or injury origin.

In intensive production systems, where large groups of relatively young animals are kept in confinement with limited airspace and in close contact, infectious diseases tend to predominate. Under such conditions infections may spread easily through direct contact, short-distance airborne transmission, or fecal uptake. This means that diseases may from time to time become a problem for animal welfare and production economy. Therefore, a number of strategies have been developed to eliminate or control the risk of infectious disease development.

The immune response of the animals is the major defense mechanism against infection. When the balance between immunity and infection is disturbed disease may develop. The severity of disease outbreaks may also be influenced by the environment, management procedures, hygiene level, and the nutritional status of animals.

Methods for Reduction of Infectious Diseases

Infectious disease limiting systems may be categorized into two main types:

1. Disease control systems that rely on a balance between infection, immunity, and management resulting in the absence of clinical disease.
2. Disease eradication systems that rely on the absence of specified infectious agents.

The first category includes changes in management, such as improved hygiene, immunization programs, and treatment with antibiotics. Hygiene measures and immunization are relevant for all types of infection, whether it is viral, bacterial, or parasitic in nature, whereas treatment with antibiotics is directed only against bacterial infections.

The second category includes specific pathogen free (SPF) production, national eradication campaigns, and programs for elimination of infections from herds.

Independent of disease control strategy a strict biosecurity program should be established in order to keep new infections out of herds. This is important for infections, which are endemic to a given region, and for transboundary infections that may spread from other parts of the world.

Infectious Disease Control

Infectious disease control is defined as an effort to live with the pathogens in a balance with immunity and management. This means that the infection may still be present in a subclinical form, but a mixture of immunity, antibiotic treatments, and low infection pressure will keep it under control.

Vaccination Programs

Vaccination is a commonly used method for the control of infections. Most often vaccination will protect against clinical disease, but not prevent animals from becoming infected carriers. In pig production there are three main vaccination strategies:

1. protection of piglets by immunization of sows and transfer of passive immunity via colostrum,
2. vaccination of individual animals in order to induce immunity to subsequent infection, and
3. vaccination of breeding animals in order to induce immunity to infections, which may impair the reproductive performance.

Typical vaccines in group 1 include *Escherichia coli* neonatal diarrhea, erysipelas, necrotizing clostridial enteritis, porcine reproductive and respiratory syndrome (PRRS), and postweaning multisystemic wasting syndrome (PMWS). Typical group 2 vaccines include pleuropneumonia, *Lawsonia intracellularis*, *Haemophilus parasuis*, PMWS, and PRRS. Typical group 3 vaccines include Porcine Parvovirus, PRRS, and PMWS.

Antibiotic Treatment Programs

Treatment with antibiotics is another important method for control of infections in pig herds.

For many years antibiotic growth promoters, in so-called subtherapeutic doses, were included in feed in order to enhance growth and control subclinical disease. The European Union banned this use in the year 2006, due to risk of resistance development and transfer of bacterial resistance to human bacterial pathogens. Antibiotic growth promoters are still used in other parts of the world, although the use is controversial.

Therapeutic treatment programs in pig herds must be based on a precise diagnosis, including herd history, clinical signs, and laboratory findings. Depending on the prevalence of disease and the risk of spread, it may be decided to use batch medication or individual animal treatment. It is important to follow approved guidelines for doses and treatment periods in order to reduce development of resistance. Certain antibiotics that are critical for human treatment should be avoided in pig production. These antibiotics include Quinolones and Cephalosporins. Development of resistance against these first-line antibiotics in zoonotic bacteria, such as *salmonella* and *campylobacter*, may cause life-threatening treatment failure in humans.

The main routes of administration of antibiotic compounds to pigs are medicated water or feed and individual

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animal injections. An advantage of injections is that the individual animal dose is well defined. The disadvantage of this administration is the amount of work involved, and the diagnostic difficulties in identification of animals suffering from subclinical infections.

Water and feed medication programs will result in a much more variable dosing of the individual pigs due to variation in disease severity, mobility, and social rank. Unfortunately, the most severely affected animals tend to stop eating and eventually also drinking, which means that the diseased animals will receive lower doses than the healthy ones.

Infectious Disease Elimination

National Eradication Programs

Several important transboundary pig diseases have been eradicated nationwide, especially in Europe and the United States. Such infections include classical and African swine fever, foot-and-mouth disease, and Aujeszky's disease. More recently Enzootic pneumonia caused by *Mycoplasma hyopneumoniae* has been eradicated from countries like Switzerland, Finland, and Norway. So far, the important viral infection PRRS has never been eradicated when established in a country. However, Sweden succeeded in stamping out the first outbreaks, and thereby prevented further spread of the disease in the country.

Successful national programs require that spread and transmission of infections is arrested and that diagnostic procedures for correct distinction between infected and non-infected herds are available. Strategies for national eradication include 'stamping out' where all animals in a positive herds are culled, or 'test and slaughter' where single animals are tested and culled. Stamping out has been used in Europe for infections such as foot-and-mouth disease and classical swine fever. Test and slaughter has been used for eradication of Aujeszky's disease. Eradication programs with culling and slaughtering of large numbers of animals will probably not be acceptable for the public in the future. Therefore, more focus is put on vaccination strategies where vaccination zones are used to create barriers for spread of infection. For this purpose so-called DIVA (differentiating infected from vaccinated animals) vaccines are useful in eradication programs because they allow destruction of infected animals while animals protected by vaccines may be slaughtered and consumed.

Eradication Programs at the Herd Level

Individual herd owners may decide to eradicate infections due to economic losses or welfare problems. In herds selling breeding animals, a high health status is particularly relevant. It is important to consider the risk of reintroduction before investing time and money in a herdwise eradication program. Herds located downwind within a distance of 2–3 km should be considered a risk factor for windborne infections such as *M. hyopneumoniae* and PRRS.

Eradication with Total Depopulation

Eradication based on total depopulation may be achieved by removal of all animals followed by cleaning, disinfection, and an empty period of 2–3 weeks. After this down period new animals with a well-defined SPF status may be inserted. By this method it is possible to obtain freedom from several infections in a single process.

Eradication with Remaining Breeding Stock

More recently, protocols for eradication of infections where the breeding animals remain at the farm during the program have been developed. The advantage of such programs is that the period with economic losses due to reduced production is shorter.

Eradication of *M. hyopneumoniae* has been a model for eradication programs where the breeding animals are retained on the farm. Eradication of this infection is facilitated by a strong immunity that develops in convalescent animals which in practice means that they clear the infection. The initial programs were developed in small herds in Switzerland in the 1970s. In Denmark the same principles have been used in herds with 1000 sows or more.

The original principles for herd eradication consisted of:

1. stabilization of herd by vaccination or development of natural immunity,
2. removal of all animals younger than 10 months,
3. two weeks farrowing stop,
4. cleaning and disinfection of infected premises, and
5. medication of remaining animals >10 months.

During the years these principles have been simplified, and it has been shown that eradication may be successful even without removal of piglets from the farrowing unit.

At present eradication herdwise programs with success rates between 80% and 100% exist for *M. hyopneumoniae*, PRRS, *Brachyspira hyodysenteriae*, and Mange (*Sarcoptes scabei*) in Denmark. Programs with higher risk of failure have been developed for *Actinobacillus pleuropneumoniae*, toxigenic *Pasteurella multocida*, and *Lawsonia intracellularis*.

Specific Pathogen Free Production

The term SPF is an abbreviation for 'specific pathogen free.' 'Specific' means that certain well-defined pathogens among numerous more or less well-defined causes of disease are included. 'Pathogen free' means that herds are free, not only from clinical disease or subclinical infection, but also from the infectious pathogen as such. The number of pathogens that a given SPF herd is free from may differ according to the ambitions of the farmer. SPF production may be used for all animal species, but it has been developed for pig production in particular.

The early SPF techniques were inspired from research on cesarean sections and germ-free rearing of pigs. This research showed that freedom from pathogens in pig populations could be maintained after establishment of a clean source.

The first commercial farms were established in the 1950s in the United States and since then several systems have been developed in North America and Europe. The Danish SPF program was established in 1968 and is, by far, the largest

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system with 250 breeding and multiplying herds and 3500 herds producing pigs for slaughter. The impact of SPF production on Danish pig production and export is huge because more than 75% of the sows delivering slaughter pigs and more than 90% of the breeding and multiplying animals have SPF status.

The advantage of SPF production is that animals with a guaranteed freedom from specific infections may be obtained. Freedom from infection and subsequent disease leads to increased growth rate and feed conversion ratio and reduced mortality. This leads to improved economic results and to a more stable production. Improved animal welfare and reduced antibiotic consumption are additional benefits from improved health status.

SPF production is based on the following principles:

1. Herds are established after careful cleaning and disinfection.
2. A strict biosecurity program preventing reintroduction is established.
3. Transport of animals between herds is carried out in special trucks with filtered air-inlets.
4. Openness about information on reintroductions of infections.
5. Monitoring by farmers, vets, and by laboratory testing.
6. Quarantine of visitors and vets coming from herds with lower health status.

Specific Pathogen Free Diseases

It is expensive to monitor, test, and declare freedom of pathogens. Therefore, it must be carefully considered which pathogens are relevant to include in the SPF system. Only infections with considerable economic impact and a well-defined and preferably cheap diagnosis should be included. It is also important that the infections are predominately transmitted by pigs. Infections transmitted by humans, rodents, feed, or bedding should be avoided. In Table 1 the infections included in the Danish SPF system are given.

A 'perfect' disease in an SPF program has a well-defined causal pathogen that may be laboratory confirmed by low-cost diagnostic tests with a high sensitivity and specificity. Such tests are most often serological testing of blood samples or automated polymerase chain reaction (PCR) tests.

Biosecurity and Introduction of Infections

Strict rules on biosecurity are cornerstones in SPF production, and have been advantageous for pig production in general. Biosecurity rules of the Danish SPF system are presented in Table 2.

Although biosecurity rules are enforced, approximately 20% of Danish SPF herds will experience introductions of unwanted infections each year (Figure 1). The highest number of introductions is experienced for *M. hyopneumoniae* and PRRS. It is well known that these infections are spreading by wind over distances as far as 2–3 km, and it is, therefore, assumed that the main route of infection is airborne from infected herds in the neighborhood.

Table 1 Major infections in pig herds that may be controlled by specific pathogen free production

- *Mycoplasma hyopneumoniae*
- *Actinobacillus pleuropneumoniae*
- Porcine reproductive and respiratory syndrome virus
- Toxigenic *Pasteurella multocida*
- *Brachyspira hyodysenteriae*
- *Haematopinus suis*
- *Sarcoptes scabiei*

Table 2 Biosecurity specifications and procedures in the Danish specific pathogen free (SPF) system

Entry of animals
Semen from controlled boar studs
Pigs from herds with equal or higher SPF status
Piglets from non-SPF herds after C-section
An 8-week quarantine period for pigs before entry in breeding herds
Only neutered cats from urban communities
Pest controlled properly
Bird entry avoided
Entry of humans
Twelve hours quarantine after contact with pigs of lower health status
No quarantine after contact with pigs of equal or higher SPF status
Change of footwear
Change of cloth to the level of underwear
Washing of hands
Minimum distance to neighboring herds
100 m for production herds
500 m for breeding and multiplying herds
Perimeter of production facilities
Well-defined borders of the production area
Entrance must be marked with SPF status
All external doors must be locked up
Special compartments for pigs leaving the farm
No direct contact between trucks and the production facilities
Safe procedures for entry of feed and bedding
Transport of pigs between herds
Only approved transporters with especially designed trucks
Air inlet filters to avoid infection by air under transport
Health monitoring in SPF herds
Clinical inspection
Fifteen weeks intervals in production herds
Monthly intervals in breeding herds
Testing for Ap, Myc, and PRRS in blood samples
Yearly in production herds
Monthly in breeding herds
Clinical suspicion of infection
Six weeks investing period
Openness to the public
All information on SPF status may be accessed on www.spf-sus.dk

Actinobacillus pleuropneumoniae is also among the more prevalent causes of infections in the Danish SPF program. Although this infection may also spread by airborne transmission over short distances, it is believed that this is rarely the case. The monitoring of this infection by blood testing is complex because more than 12 serotypes exit, which may partly contribute to the spread of this infection.

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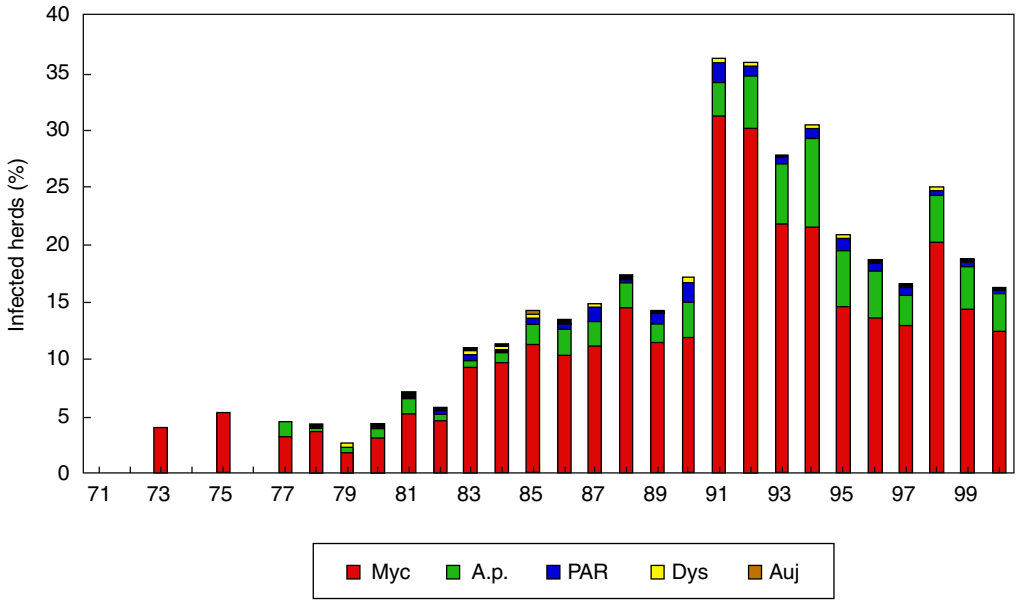

Figure 1 Infection episodes in Danish SPF system, including approximately 3500 production and breeding herds in the period 1985–2000.

Infections with *B. hyodysenteriae*, *Sarcoptes scabei*, and toxigenic *P. multocida* are very infrequent in the Danish SPF system.

Conclusions

Infectious disease reduction in pig herds may be based on a control strategy (living with the infection) or an eradication strategy (SPF). The strategy must be chosen by individual farmers, regions, or nations based on the pig density in areas, the structure of the pig production, and the cost and consequences of disease.

The advantage of the control strategy is that a balance between infection, immunity, and management may be obtained leaving the herd well protected against new infections. The disadvantages are that this strategy may require permanent costs for vaccination, treatment, and eventually disease outbreaks when the balance is disturbed.

The advantage of the eradication strategy is that once the infection is totally eliminated, there will be no more cost or losses as a result of the corresponding disease. This is a very rewarding situation. Disadvantages include that monitoring efforts may be costly and that such herds always are at risk of introduction of the infections they are free from, in particular those that may be transmitted through air.

See also: Foodborne Zoonoses. Meat, Animal, Poultry and Fish Production and Management: Antibiotic Growth Promotants; Beta-Agonists; Bovine and Porcine Somatotropin; Meat Production in Organic Farming. Meat-Borne Hazards, Concepts and Methods for Mitigating Risks Related to. Microorganisms and Resistance to Antibiotics, the Ubiquity of: Antibiotic Resistance by Microorganisms; Potential Environmental and Wildlife Sources of Microorganisms in Meat. Parasites Present in Meat and Viscera of Land Farmed Animals. Preslaughter Handling: Welfare Including Housing Conditions; Welfare of Animals. Quality Management: Farm Level: Pork Quality. Risk Analysis and Quantitative Risk Management

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